Journal of Genetic Counseling (2018) 27:863–873
https://doi.org/10.1007/s10897-017-0194-4

ORIGINAL RESEARCH

Breast Cancer Genetics Knowledge and Testing Intentions among Nigerian Professional Women

Samuel O. Ngene[1] · Babatunde Adedokun[1] · Prisca Adejumo[2] · Olufunmilayo Olopade[3]

Received: 2 February 2017 / Accepted: 12 December 2017 / Published online: 19 December 2017

Abstract
Genetic testing services for breast cancer are well established in developed countries compared to African populations that bear a disproportionate burden of breast cancer (BC). The objective of this study is to examine the knowledge of professional Nigerian women about BC genetics and their intentions to utilize genetic testing services when it is made available in Nigeria. In this study, 165 lecturers and 189 bankers were recruited and studied using a validated self-administered questionnaire. The respondents' mean age was 34.9 years (SD = 10.9), 6.5% had family history of BC, and 84.7% had limited knowledge of breast cancer genetics. The proportion of women with genetic testing intentions for breast cancer was 87.3%. Health care access (OR = 2.35, 95% CI, 1.07–5.13), religion (OR = 3.51, 95% CI, 1.03–11.92), and perceived personal risk if a close relative had breast cancer (OR = 2.31, 95% CI, 1.05–5.08) independently predicted testing intentions. The genetic testing intentions for BC were high despite limited knowledge about breast cancer genetics. Promotion of BC genetics education as well as efforts to make BC genetic testing services available in Nigeria at reduced cost remains essential.

Keywords Willingness · Professional women · Genetic testing · *BRCA 1* · *BRCA 2* · Breast cancer · Nigeria

Introduction

Breast cancer (BC) is the most important cancer in women globally, with more than double the incidence from 641,000 new cases in 1980 to about 1.64 million cases in 2010 (Forouzanfar et al. 2011). Breast cancer is now the most common female cancer in Nigeria with an age-standardized incidence of about 54 per 100,000, using data from two major Nigerian cancer registries (Jedy-Agba et al. 2012). In developing countries, breast cancer is the leading cause of cancer deaths and accounts for 34.2% of total cancer deaths among Nigerian women (World Health Organization 2014). A key challenge with management of breast cancer in Nigeria is the late presentation of patients with advanced disease with very poor chance of survival (Adebamowo and Ajayi 2000; Sitas et al. 2008).

Prevention of breast cancer remains key to the control of the disease in developing countries. However, in spite of poor outcomes among breast cancer patients in Nigeria, there is a relatively low level of knowledge about risk factors for the disease and poor awareness and utilization of screening services. Studies in Nigeria have shown that only about 5% of women have heard of or ever had a mammography done (Akinola et al. 2011; Obajimi et al. 2013).

Genetic factors play an important role in the etiology of breast cancer and provide options for prevention of the disease. The *BRCA* genes were identified in the 90s, and they have been implicated as an important risk factor for the disease. Mutation in the *BRCA 1* and *BRCA* 2 genes is found in about 5–10% of breast cancer cases, and individuals with these mutations have a 40–66% cumulative risk of breast cancer (Antoniou et al. 2003; Chen and Parmigiani 2007; Easton

✉ Samuel O. Ngene
ngsmary1916@gmail.com

Babatunde Adedokun
tukankar@yahoo.co.uk

Prisca Adejumo
bisiandbayo@yahoo.com

Olufunmilayo Olopade
folopade@medicine.bsd.uchicago.edu

[1] Department of Epidemiology and Medical Statistics, College of Medicine, University of Ibadan, Ibadan, Nigeria

[2] Department of Nursing, University of Ibadan, Ibadan, Nigeria

[3] Department of Medicine, University of Chicago, Chicago, IL, USA

et al. 2015; Mavaddat et al. 2013; Miki et al. 1994). Mutation in the *BRCA* genes is also associated with earlier age of onset and higher mortality of BC among African women (Fackenthal et al. 2005).

Genetic testing for the *BRCA* genes has been commercially available in developed countries and allows for informed decision making for breast cancer patients and their female relatives, women at high risk of breast cancer, and the general population. The benefits of commercial genetic testing include the following: determination of chance of recurrence among breast cancer patients, selection of early cancer detection and risk reduction strategies, and reassurance for family members of breast cancer patients (Dandara et al. 2013; Su 2013). There are, however, ethical concerns about cost, accuracy of test results, the handling of positive screening results, and discrimination of those with positive screening results by insurance companies (Caulfield et al. 2010; Dandara et al. 2013; Su 2013; Tong 2013).

Studies have consistently shown a high level of interest in genetic testing for breast cancer and other hereditary diseases in developed countries (Botoseneanu et al. 2011; Halbert et al. 2005; Kessler et al. 2005; Satia et al. 2006). However, such studies are scarce in sub-Saharan Africa (SSA). One of the very few studies in SSA was done by Fagbemiro and Adebamowo (2014) who investigated knowledge about genomics and attitudes towards personal genomics testing among apparently healthy adults, patients with complex diseases and their relatives, health workers, and community leaders, in rural and urban Nigerian communities. Using qualitative methodology, the researchers found a low level of knowledge about genomics and genomics testing among all participants. However, the attitudes of respondents to genomic tests were generally positive.

Purpose of the Study

Advances in genomic medicine hold great promise for healthcare in developing countries. However, there are concerns about greater inequalities in health and access to services as many genomics products may not be affordable to a majority of the populace in resource poor countries such as Nigeria (World Health Organization 2002). The increasing application of genomics technologies in medicine will eventually spread to developing nations in Africa, including Nigeria. Thus, there is a need to understand the level of awareness and interest in genetic testing for common diseases such as breast cancer if those services are available in Nigeria. In this study, we studied the knowledge of breast cancer genetics and interest in genetic testing among women of higher educational level in private and public sectors in Ibadan, Nigeria.

Methods

Study Design, Area, and Setting

This was a cross-sectional study conducted among women aged 18 years and above in Ibadan, Oyo state. Ibadan is the largest indigenous city in West Africa and is located in the South Western part of Nigeria. It is the capital of Oyo state and made up of 11 Local Government Areas with a total land area of 3123 km^2 and a population of 2,550,593, according to 2006 census results. The inhabitants are predominantly civil servants and private business owners. The University of Ibadan is the oldest university in Nigeria, located in Oyo state, Southwest Nigeria. It has two main campuses, one for the College of Medicine and the other for all other faculties. The faculties include Arts, Sciences, Social Sciences, Technology, Education, Agriculture and Forestry, Pharmacy, Basic medical Sciences, Public Health, and Clinical Sciences. The College of Medicine and the Faculty of Pharmacy were excluded from the study. The institution has 1549 teaching staff of which 424 are females. There are several branches of 15 banks located in various parts of the city of Ibadan.

Study Participants

The population of interest are female bankers and university lecturers, aged 18 years and above, who were not on leave at the time of data collection.

Sampling

A multistage sampling procedure was used to select the two groups of women. The simple random sampling method was used at each stage for selection and was done via a computer-generated set of numbers after generating a sampling frame at each stage. We selected female bankers working in the four local governments in Ibadan metropolis (Ibadan North, Ibadan North West, Ibadan South West, and Ibadan North East). There are about 15 different banks in Oyo State, of which most bank outlets are located in Ibadan North West and Ibadan North local governments. In the first stage, ten different banks in Ibadan metropolis were randomly selected and the number of women to be studied in each bank determined by proportional allocation. In the second stage, the number of branches of each bank studied was determined proportionate to the number of branches for each bank. In the third stage, the number of female bankers selected from each branch was shared equally between the branches selected at the second stage.

The selection of lecturers was a three-stage procedure where faculties in the College of Medicine and Pharmacy were excluded from the sampling frame of all faculties at the University of Ibadan. From the remainder, ten faculties were

selected. Six departments each were randomly selected from the chosen faculties. The number of female lecturers selected from each department was determined using proportional allocation.

Study Procedures, Data Collection, and Survey Instruments

Female lecturers were studied at their departments in the university. After obtaining the list of eligible participants in each department and completion of sampling, the women were visited in their offices, the study was explained to them and consent was obtained. The questionnaires were completed and collected immediately for some participants. However, we made repeated visits for up to three visits for other women for retrieval of questionnaires. A similar approach was used for data collection among bankers. There were 189 out of 232 bankers and 165 out of 182 lectures from whom questionnaires were eventually obtained, with response rates of 81.5 and 90.7%, respectively.

Self-administered questionnaires including 81 items were used to obtain information about the women's socio-demographic characteristics, level of utilization of breast cancer screening services, knowledge of breast cancer genetics, and willingness to have genetic testing for breast cancer. The questions on utilization of breast cancer screening services and willingness to have genetic testing were closed ended with "Yes" or "No" options. Knowledge of breast cancer genetics was determined using 12 true or false questions adapted from previous studies (Amin et al. 2012; Bruno et al. 2004; Kinney et al. 2010; Lerman et al. 1997; Lerman et al. 1996). The items from these studies were from a standardized and validated questionnaire from the National Human Genome Research Institute with good psychometric properties.

Ethical Considerations

The Oyo State Ethics Review Committee gave ethical approval for this research, and each consenting participant signed the informed consent form.

Data Management and Analysis

Data were analyzed using SPSS version 16. Descriptive statistics were used to depict the general characteristics of the sample. Knowledge of BC genetics, which was categorized into good (> 6 correct answers) and poor (≤ 6 correct answers), was the dependent variable, while independent variables were factors such as occupation, age, marital status, religion, income, family history of BC, awareness and utilization of BC screening services, awareness of *BRCA* genes, perceived risk, willingness to have genetic testing for breast cancer, and knowledge of BC risk factors. Chi-square test was used to analyze the association between categorical variables and willingness to have genetic testing for breast cancer. Chi-square tests were conducted to identify variables that had significant associations. Significant variables from the chi-square tests were further analyzed using multiple logistic regression to identify factors that were independently associated with the women's willingness to have genetic testing for breast cancer. A probability level of $p < 0.05$ was accepted as being of statistical significance.

Results

Socio-demographic Characteristics and Family History of Cancer

Data were available for 189 bankers and 165 lecturers. The respondents' ages ranged from 18 to 67 years, with a mean age of 34.9 years (SD = 10.9 years). Two hundred twenty-two (62.7%) had ever married, and most (82.2%) were Christians. Almost two-thirds (61.9%) paid for healthcare out of pocket. Twenty-three (6.5%) indicated a family history of breast cancer, two (0.6%) of ovarian cancer, and 19 (5.4%) of other cancers, while 312 (88.1%) had no family history of cancer (Table 1).

Table 1 Socio-demographic characteristics and family history of cancer among respondents ($N = 354$)

Variables	Frequency (n)	Percentage (%)
Occupation		
Lecturers	165	46.6
Bankers	189	53.4
Ages		
18–24	74	20.9
25–34	115	32.5
35–67	165	46.6
Marital status		
Ever married	222	62.7
Never married	132	37.3
Religion		
Christianity	291	82.2
Islam	63	17.8
Family history of cancer		
Breast cancer	23	6.5
Ovarian cancer	2	0.6
Other cancer	17	4.8
None	312	88.1
Health care access		
Out of pocket	219	61.9
Insurance	135	38.1

Awareness and Utilization of Breast Cancer Screening

Most of the respondents, 298 (84.2%) were aware of breast cancer screening services, but only 169 (47.7%) had utilized these services. The commonly utilized breast cancer screening method was breast self-examination 144 (85.2%), while the least utilized methods were clinical breast-examination 20 (11.8%) and mammography 18 (10.7%).

Knowledge of Breast Cancer Genetics and Associated Factors

Less than one quarter (13.6%) had heard about *BRCA 1* or *BRCA 2* genes. Among those aware of the genes, 27 (36.0%) knew about it from the internet and 34.6% from radio/television. Other sources of information mentioned include the following: hospital (8%), relatives (8.0%), conferences (9.3%), and books/posters (4.0%). About one third (35.7%) perceived that they would be at risk of breast cancer if their close relative had an altered *BRCA 1* or *BRCA 2*.

The mean knowledge score for breast cancer genetics was 3.2 (SD = 2.7; range = 0–12) out of a total of 12. Less than one quarter (15.3%) had a score of above 6, and they were classified as having good knowledge. Table 2 shows the proportion of particpants with correct responses to the knowledge items on breast cancer genetics for the total sample and also for each group (bankers and lecturers). Forty six participants (13.0%) responded correctly to the statement that everybody has breast cancer gene. One hundred twenty-three participants (34.7%) correctly responded to the statement that all women with breast cancer gene will develop breast cancer. Only 13.8% knew that the population prevalence of breast cancer gene mutation was not 1 in 10, while 37.3 and 18.4% knew that mutated breast cancer gene increases the risk of breast and ovarian cancer, respectively. Over three quarters (77.4%) did not know that an altered breast cancer gene could be inherited from one's biological father. The role of BC genes in the development of BC before the age of 40 years was correctly stated by 21.8% of the respondents, while 43.5% were aware of the availability of breast cancer genes testing. Compared to bankers, a significantly higher proportion of lecturers gave correct answers to items: "A woman who has her breasts removed can still get BC" ($p = 0.001$) and "All women with BC gene will develop BC" ($p = 0.030$).

Cross-tabulations and multiple logistic regression analysis of knowledge of BC genetics on variables are shown in Table 3. Cross-tabulations showed significantly higher proportions with good knowledge were found among lecturers, Christians, those with perceived risk of breast cancer, and with good knowledge of breast cancer risk factors. In the multiple logistic regression analysis, two variables, religion and knowledge of breast cancer risk factors, remained significant.

Table 2 Participants' responses regarding their knowledge of breast cancer genetics

Knowledge questions (true or false)	*n* (%) of correct responses Bankers (*n* = 189)	*n* (%) of correct responses Lecturers (*n* = 165)	*n* (%) of correct responses Total sample (*N* = 354)	*p* value
Everybody has BC gene (true)	29 (15.3)	17 (10.3)	46 (13.0)	0.159
All women with BC gene will develop BC (false)	56 (29.6)	67 (40.6)	123 (34.7)	0.030
A woman who has her breasts removed can still get BC (true)	42 (22.2)	63 (38.2)	105 (29.7)	0.001
About one in every ten women have an altered BC gene (false)	31 (16.4)	18 (10.9)	49 (13.8)	0.135
All women who have an altered breast gene get BC (false)	44 (23.3)	31 (18.8)	75 (21.2)	0.302
A woman who does not have an altered (mutated) BC gene can still get BC (true)	60 (31.7)	48 (29.1)	108 (30.5)	0.588
A woman with altered BC gene has a higher chance of getting BC (true)	63 (33.3)	69 (41.8)	132 (37.3)	0.100
A woman with altered breast cancer gene has a higher chance of getting ovarian cancer (true)	31 (16.4)	34 (20.6)	65 (18.4)	0.308
A father can pass down an altered BC gene to his daughter (true)	38 (20.1)	42 (25.5)	80 (22.6)	0.230
A woman who has a sister with an altered breast cancer gene has a 50% chance of also having an altered breast cancer gene (true)	57 (30.2)	64 (38.8)	121 (34.2)	0.088
Early onset (less than 40 years)of breast cancer is more likely to be due to an altered gene than late onset breast cancer (true)	34 (18.0)	43 (26.1)	77 (21.8)	0.066
There are tests currently available to detect altered breast cancer genes (true)	77 (40.7)	77 (46.7)	154 (43.5)	0.262

Table 3 Cross-tabulations and multiple logistic regression of participants' knowledge of BC genetics and independent variables

Independent variables	Cross-tabulations			Multiple regression		
	% with good knowledge *n (%)*	Total	*p* value	OR	95% CI OR	*p* value
Occupation						
Lecturers	32 (19.4)	165	*0.043*	1.09	0.39–3.02	0.875
Bankers	22 (11.6)	189		Ref.		
Age						
18–24	6 (8.1)	74	0.072	Ref.		
25–34	16 (13.9)	155		1.83	0.63–5.26	0.265
35–67	32 (19.4)	165		2.31	0.60–8.82	0.223
Marital status						
Ever married	37 (16.7)	222	0.338			
Never married	17 (12.9)	132				
Religion						
Christianity	50 (17.2)	291	*0.030*	3.15	1.05–9.49	*0.041*
Islam	4 (6.3)	63		Ref.		
Monthly income						
Less than #100,000	18 (12.2)	148	0.231			
#100,000–#200,000	22 (15.7)	140				
Above #200,000	14 (21.2)	66				
Family history of BC						
Yes	7 (17.9)	39	0.879			
No	44 (14.9)	296				
I am not sure	3 (15.8)	19				
Ever utilized any breast cancer screening services?						
Yes	30 (17.8)	169	0.212			
No	24 (13.0)	185				
Perceived risk if a close relative had altered *BRCA 1* or *BRCA 2*						
Yes	30 (24.4)	123	*0.003*	2.66	1.00–7.07	0.050
No	18 (12.1)	149		1.56	0.58–4.21	0.382
I do not know	6 (8.2)	73		Ref.		
Knowledge of BC risk factors						
Good knowledge (> 9)	21 (39.6)	53	*< 0.001*	4.39	2.16–8.92	*< 0.001*
Poor knowledge (≤ 9)	33 (11.0)	301		Ref.		

Ref reference category, *OR* odds ratio, *CI* confidence interval

R^2 = 0.101, Hosmer Lemeshow *p* value = 0.757

Breast Cancer Genetic Testing Intentions and Associated Factors

Most of the respondents (87.3%) unconditionally indicated intentions to have genetic testing for BC if it is made available in Nigeria, and the same proportion would only access the BC genetic testing services when a close relative has breast or ovarian cancer. About nine in ten women (89.5%) would be more willing to utilize genetic testing for BC when it is done at no cost. Only about one tenth (11.2%) of the participants were willing to pay at least #60,000 for genetic tests while a larger proportion 238 (88.8%) would afford less than #60,000.

Cross-tabulations and multiple logistic regression analysis of genetic testing intentions and independent variables are shown in Table 4. Muslims were more willing than Christians to have genetic testing for breast cancer. Also significantly associated on crosstabulations were awareness of breast cancer screening services, perceived risk, and health care access. These variables remained significant in the logistic regression analsyis, with the exception of awareness of breast cancer screening services.

Table 4 Cross-tabulations and multiple logistic regression of participants' genetic testing intention and independent variables

Independent variables	Cross-tabulations			Multiple regression		
	Genetic testing intention *n* (%)	Total	*p* value	OR	95% CI OR	*p* value
Occupation						
Lecturers	146 (88.5)	165	0.528			
Bankers	163 (86.2)	189				
Age						
18–24	62 (83.8)	74	0.508			
25–34	103 (89.6)	115				
35–67	144 (87.3)	165				
Marital status						
Ever married	196 (88.3)	222	0.464			
Never married	113 (85.6)	132				
Religion						
Christianity	249 (85.6)	291	*0.037*	Ref.		
Islam	60 (95.2)	63		3.51	1.03–11.92	*0.044*
Monthly income						
Less than #100,000	127 (85.8)	148	0.377			
#100,000–#200,000	121 (86.4)	140				
Above #200,000	61 (92.4)	66				
Family history of BC						
Yes	35 (89.7)	39	0.828			
No	258 (87.2)	296				
Not sure	16 (84.2)	19				
Aware of any breast cancer screening services?						
Yes	266 (89.3)	298	*0.010*	2.08	0.94–4.60	0.071
No	43 (76.8)	56		Ref		
Heard of the breast cancer gene called *BRCA 1* or *BRCA 2?*						
Yes	44 (91.7)	48	0.327			
No	265 (86.1)	306				
Perceived risk if close relative had altered *BRCA 1* or *BRCA 2*						
Yes	113 (91.9)	123	*0.048*	2.31	1.05–5.08	*0.040*
I do not know	66 (90.4)	73		2.06		0.364
No	123 (82.6)	149		Ref.	0.83–5.09	
Health care access						
Out of pocket	184 (84.0)	219		Ref	1.07–5.13	*0.033*
Insurance	125 (92.6)	135	*0.019*	2.35		
Knowledge of breast cancer genetics						
Good knowledge (> 6)	49 (90.7)	54	0.408			
Poor knowledge (≤ 6)	260 (86.7)	300				

Ref reference category, *OR* odds ratio, *CI* confidence interval

$R^2 = 0.057$, Hosmer Lemeshow *p* value = 0.964

Discussion

This study has shown a high level of willingness of educated Nigerian women to utilize genetic testing for BC; however, their knowledge about breast cancer genetics was poor. To our knowledge, there are few studies in sub-Saharan Arica that have investigated the knowledge of cancer genetics in any population. Additionally, the focus of this study is on breast cancer, the most common cancer in Nigeria, and it provides some information about the knowledge and disposition of Nigerian women to the genetics-related options available for prevention and prognosis of the disease.

Findings from this study revealed that a large majority (84.2%) of the respondents were aware of breast cancer screening services, but only about half had utilized these services. This finding is similar to that reported by a recent Nigerian study (Olajide et al. 2014). Assessment of the various early detection methods in this present study revealed that about seven in ten participants have ever had BSE. Our finding is in concordance with the BSE practice rate of 77.6% among female health workers in Edo, Nigeria (Akhigbe and Omuemu 2009). Suh et al. (2012), in a survey among women in Buea, Cameroon, found that about 60% have had BSE. Findings from a study among Iranian women reported a BSE practice rate of 61% (Montazeri et al. 2008), and Olajide et al. (2014) reported that 56% of the BC patients attending clinic in Lagos have ever had BSE. In contrast, Obaji et al. (2013) reported a low-BSE practice of 21.8% among market women in South East Nigeria, an indication of the role of educational level and/or social class on the awareness of breast cancer screening services.

Compared to BSE, the practice of CBE was low at about 12% in this study, similar to 9% reported by Okobia et al. (2006) among community dwellers, but lower than 26% reported by Ibrahim and Odusanya (2009) among female health care professionals in Lagos, Nigeria. The least utilized BC screening method found in this study was mammography (reported in about one tenth of women surveyed). This is consistent with a study among nurses in Lagos that reported 7.8% (Odusanya and Tayo 2001). Also, Akhigbe and Omuemu (2009) reported a lower mammography rate of 3.1% among female health workers in Benin, South east Nigeria, while Obajimi et al. (2013) found that none of the women attending outpatient clinics in a teaching hospital in Ibadan, South-West Nigeria, have ever had mammography.

The present sample of women studied had poor knowledge of BC genetics. The mean BC genetics knowledge score was 3.2 (out of a total of 12) with a knowledge deficit of 86.4%. This finding is in consonance with other studies. Amin et al. (2012) reported a median knowledge score of 1 (out of 7 points) with knowledge deficit of 87.8% among Saudi women. Two older studies of knowledge of breast cancer genetics among high-risk African American women had an average knowledge score of 4.55 of a total of 11 (Hughes et al. 1997) and 3.2 out of 9, respectively (Kinney et al. 2001). More recent studies similarly report poor genetics knowledge among African Americans (Sheppard et al. 2014; Spruill et al. 2009; Kessler et al. 2007). Our study also revealed that only 13.6% of the women have heard about *BRCA 1* or *BRCA 2*. This is similar to the findings of Durfy et al. (1999) who found that 10% of African American women with family history of BC had heard of genetic testing for cancer risk. All other studies reported a higher level of awareness of BC genes ranging from 19 to 96% among cancer patients and the general population (Amin et al. 2012; Armstrong et al. 2012; Bottorff et al. 2002; Bruno et al. 2010; Hughes et al. 1997; MacNew et al. 2010; Mogilner et al. 1998).

Concerning specific questions asked about breast cancer genetics, knowledge of the role of the paternal family history of breast cancer was poor in the present study (22.6%). This is lower when compared with the findings of other studies conducted in developed countries that range from 37 to 75% (Amin et al. 2012; Bottorff et al. 2002; Hughes et al. 1997; Kinney et al. 2001; Peters et al. 2005). However, the proportion of women that knew the prevalence of breast cancer gene (14%) observed in this study is similar to the 5 to 14% reported by other studies (Bottorff et al. 2002; Hughes et al. 1997; Kinney et al. 2001). Meanwhile, Peters et al. (2005) reported a higher knowledge of the prevalence of BC genes of 44% among the general population and 70% among those who have tested for a BC gene among American women. The difference found in the latter may be due to the fact that all the respondents were aware of BC genetic testing.

About 44% of the respondents in this study indicated that tests are available to detect altered BC genes. Findings from other studies have shown a marked variation from this result. Amin et al. (2012) found as low as 7% among Saudi women without BC, while Bottorff et al. (2002) found a higher correct knowledge of 75 and 79% about the availability of BC genetic testing services among Canadian women without and with BC, respectively. This result is an indication that the women in developed countries are more knowledgeable about the availability of BC genetic testing services than their counterparts in developing countries.

The finding that less than one quarter (22%) knew that BC genes are responsible for the early onset of BC is similar to 15% for the same knowledge item among Saudi women by Amin et al. (2012). Concerning other knowledge items, about one third of women studied knew the importance of an altered BC gene in a sister, which is far lower compared to the 61% found by Hughes et al. (1997) among African American and Caucasian women with at least a first degree relative with BC. In addition, a study conducted by Bottorff et al. (2002) among Canadian women without BC also found that 82% of the respondents were knowledgeable about the implication of a sister's personal history of BC.

Furthermore, regarding the participants' breast cancer genetics knowledge, few of the women studied knew that a person with a BC gene has a higher chance of developing BC (37%) or ovarian cancer (18%). This finding is similar to the study conducted by Amin et al. (2012) who reported that only 12% of Saudi women knew that having an altered BC gene places one at a higher risk of developing ovarian cancer. The figures are higher from studies in the USA where Hughes et al. (1997) found that most (77%) American women knew that the chance of developing ovarian cancer is increased when one has the altered breast cancer gene. Also, Kinney et al. (2001) reported that 60% of African

Americans whose first degree relative (FDR) had *BRCA 1* mutations knew that having altered BC genes increases one's risk of developing BC or ovarian cancer. A study conducted among Americans who were all aware of *BRCA 1* and *BRCA 2* testing found that 78% knew about the increased risk of developing ovarian cancer as a result of mutation of the BC genes (Peters et al. 2005). This current study also found that only about 31% of the women knew that those without an altered BC gene can still develop BC, which is similar to the 18% reported by the study conducted among Saudi women (Amin et al. 2012). Meanwhile, this finding is different from the 57 to 98% reported by studies conducted in the USA (Bottorff et al. 2002; Hughes et al. 1997; Kinney et al. 2001; Peters et al. 2005). The generally low level of knowledge about breast cancer genetics among educated Nigerian women underscores the need for a more aggressive approach to educating women about breast cancer and screening practices for early detection.

The multiple regression model showed that Christians were three times more likely to be knowledgeable about BC genetics than Muslims, and the reason for the significant difference between religions is difficult to explain, perhaps it could reflect the association for an unmeasured variable. Also significant in the regression model was good knowledge of BC risk factors, and this finding suggests that women knowledgeable about breast cancer generally are more likely to find out about breast cancer genetics.

The genetic testing intentions of the women in our study were very positive, as almost nine in ten women indicated willingness to have genetic testing for BC. This is similar to the findings of studies conducted among African American women on genetic testing for cancers and other diseases (Botoseneanu et al. 2011; Satia et al. 2006; Halbert et al. 2005; Kessler et al. 2005). A study by MacNew et al. (2010) in Southeastern Georgia also found that 87% of the respondents indicated their willingness to have genetic testing for BC. The high level of interest in genetic testing among the women in our study could be a reflection of the increasing rates of breast cancer in Nigeria making more women interested in knowing about their risk of having the disease. Notably, genetic testing is not possible in most sub-Saharan African countries, including Nigeria, and the authors are not aware of any plans to provide the services by commercial companies. In South Africa where the services are available, there are currently no guidelines or recommendations for genetic testing (Dandara et al. 2013). It is expected, however, that as the cost of testing continues to fall in the coming years, genetic testing would become available. In a similar vein, genetic counseling services should also be made available in developing countries such as Nigeria, in view of the high level of interest in genetic testing services among women studied. Currently, genetic counseling services for high-risk women are not available in most hospitals in sub-Saharan Africa, and resources need to be devoted to the training of physicians and nurses to fill the urgent need for genetic counselors.

This study found that 56% of the women studied were willing to pay between #3000 and #60,000 (about $100 to $200) for genetic testing. This amount is comparable to that of other studies. A study conducted among a diverse sample of women with family history of BC by Durfy et al. (1999) in Western Washington revealed that most African American women (54.9%) opted to pay less than $100 compared to the white American (50.3%) that desired to pay $100 to $200. The level of willingness to pay expressed by the women in our study should also be interpreted cautiously, bearing in mind that willingness to pay for BC genetic testing may not be translated into uptake when the service is made available in Nigeria.

This study also investigated reasons for women's genetic testing intentions. The most frequently endorsed reason for testing intentions for *BRCA 1* or *BRCA 2* genes was to detect BC before it causes harm. This finding differs from results of some studies that found learning about one's children's risk was the prominent reason to have genetic testing for BC (Bottorff et al. 2002; Bruno et al. 2010; Lerman et al. 1995). Some studies among BC patients found that the most often cited reason to have genetic testing was to increase the frequency of their screening for BC (Kash et al. 2000; Struewing et al. 1995). The varied reasons given for willingness to get tested for breast cancer may be due to the difference in geographical location and population characteristics. The reason given by our studied sample may be due to the early onset of BC among Nigerians. Notably, though the proportion of women with testing intentions was high in this study, it is unclear whether this high interest was informed by potential benefits of testing such as availability of more risk reduction options, especially given the poor knowledge of breast cancer among the women studied. Moreover, we expect that positive testing intentions will translate to greater utilization of screening services among the women at high risk of breast cancer, given that uptake of screening services is currently low in Nigeria. Prospective studies are needed in the future to understand the influence of positive genetic testing results on screening behavior and acceptance of risk-reduction procedures among Nigerian women with high-breast cancer risk.

The common reason given by about half of our respondents for their unwillingness to utilize the BC genetic testing was the fear of any adverse effect that could arise from a new medical product. Compared to the study by Bruno et al. (2010), lack of trust in modern medicine was the least cited reason for unwillingness to have genetic testing for BC among women in Italy, suggesting that women in less-developed countries could be more skeptical of new technology.

The factors independently associated with genetic testing intentions on multivariable analysis were religion, health care access, and perceived risk of BC. Respondents who perceived themselves as being at risk of BC were two times more likely

than those who perceived no risk to test for BC genes. This association has been previously reported (Bellcross et al. 2015). Muslims were four times more likely than Christians to be interested in genetic testing for BC. The reason for the higher odds among Muslims is unclear, especially given that this study also found that Christians were more likely to have good knowledge about breast cancer genetics. The complex relationships among culture, religion, and issues related to genetics in traditional African societies have been described previously (Jegede 2009) and need further study. Respondents who had healthcare insurance were more likely than those paying out of pocket to desire genetic testing for BC. Similar to our findings, Hughes et al. (1997) reported that those who had health insurance are significantly more likely to have genetic testing intentions than those who had no health insurance. Nevertheless, Kinney et al. (2001) found that there was no significant association between health care access and desire to have genetic testing for BC among African American women whose first degree relative had BC.

Currently in Nigeria, a majority still pay out of pocket for health care, and this mode of health financing could make access to genetic testing services difficult even when it is made available. Furthermore, inequalities in healthcare access between women of different social classes is likely to worsen, and Nigerian women likely will benefit from subsidies in the cost of genetic testing for BC when made available, as it is the case in the USA (Moyer et al. 2014). The non-significant association between willingness to have a test and family history of breast cancer found in this study has been reported by other studies (Bruno et al. 2010; Quinlivan et al. 2014; Sanderson et al. 2004). However in our study, this finding might indicate poor knowledge of the importance of family history of breast cancer as a risk factor for the disease.

Study Limitations and Research Recommendations

Findings from this study need to be interpreted cautiously in the light of the following limitations. First, the sample is comprised of professional women representing a very small section of the population, hence the results may not be generalized to the population of women in Nigeria. Further studies are needed at community level to obtain a representative sample of Nigerian women. Secondly, we may not guarantee an informed decision-making about the intentions to have genetic testing for breast cancer given the generally low level of knowledge about breast cancer and genetics among Nigerian women. However, one of the strengths of this study include the use survey items adapted from a standardized and validated questionnaire from the National Human Genome Research Institute to assess the knowledge of breast cancer genetics among respondents. Of note, however, these items were not assessed for their reliability and validity in the present sample. Finally, the intention items used in the present study assessed hypothetical willingness, which may not reflect actual uptake.

Conclusion

Respondents in this study expressed strong willingness to have genetic testing for breast cancer despite their limited knowledge of breast cancer genetics. Most respondents were willing to pay for genetic testing for breast cancer when it is made available in Nigeria.

Willingness to get tested was significantly associated with health care access, religion, and perceived personal risk. Key to the prevention and control of breast cancer in Nigeria is improved knowledge about the risk factors for the disease and early detection methods using available screening methods. Campaigns aimed at improving the knowledge of Nigerian women about breast cancer risk factors, and available screening tests and treatment options are urgently needed to enable these women make informed decisions about their health.

Funding This study was not funded by any external body aside the authors.

Compliance with Ethical Standards

Conflict of Interest Samuel O. Ngene, Babatunde Adedokun, Prisca Adejumo, and Olufunmilayo Olopade declare that they have no conflict of interest.

Human Studies and Informed Consent All the respondents in the study gave written and signed informed consent. All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000 (5). Informed consent was obtained from all patients for being included in the study. No animal studies were carried out by the authors for this article.

Animal Studies No animal studies were carried out by the authors for this article.

Ethical Approval Ethical approval for this study was obtained from the Oyo State Research Ethics Review Committee, Ministry of Health, Ibadan, Oyo State, Nigeria.

References

Adebamowo, C. A., & Ajayi, O. O. (2000). Breast cancer in Nigeria. *West African Journal of Medicine, 19*(3), 179–191.

Akhigbe, A. O., & Omuemu, V. O. (2009). Knowledge, attitudes and practice of breast cancer screening among female health workers in a Nigerian urban city. *BioMedical Central Cancer, 9*(1), 203. https://doi.org/10.1186/1471-2407-9-203.

Akinola, R., Wright, K., Osunfidiya, O., Orogbemi, O., & Akinola, O. (2011). Mammography and mammographic screening: are female patients at a teaching hospital in Lagos, Nigeria, aware of these

procedures? *Diagnostic and Interventional Radiology, 17*(2), 125–129. https://doi.org/10.4261/1305-3825.DIR.3078-09.2.

Amin, T. T., Al-Wadaani, H. A., Al-Quaimi, M. M., Aldairi, N. A., Alkhateeb, J. M., & Al-Jaafari, A. A. (2012). Saudi women's interest in breast cancer gene testing: possible influence of awareness, perceived risk and socio-demographic factors. *Asian Pacific Journal of Cancer Prevention, 13*, 3879–3887. https://doi.org/10.7314/APJCP.2012.13.8.3879.

Antoniou, A., Pharoah, P. D. P., Narod, S., Risch, H. A., Eyfjord, J. E., Hopper, J. L., et al. (2003). Average risks of breast and ovarian cancer associated with BRCA1 or BRCA2 mutations detected in case series unselected for family history: a combined analysis of 22 studies. *American Journal of Human Genetics, 72*, 1117–1130.

Armstrong, K., Weber, B., Ubel, P. A., Guerra, C., & Schwartz, J. S. (2012). Interest in BRCA1/2 testing in a primary care population. *Preventive Medicine, 34*(6), 590–595. https://doi.org/10.1006/pmed.2002.1022.

Bellcross, C. A., Peipins, L. A., McCarty, F. A., Rodriguez, J. L., Hawkins, N. A., Alford, S. H., & Leadbetter, S. (2015). Characteristics associated with genetic counseling referral and BRCA1/2 testing among women in a large integrated health system. *Genetics in Medicine, 17*(1), 43–50.

Botoseneanu, A., Alexander, J. A., & Banaszak-Holl, J. (2011). To test or not to test? The role of attitudes, knowledge, and religious involvement among US adults on intent-to-obtain adult genetic testing. *Health Education & Behavior, 38*(6), 617–628.

Bottorff, J. L., Ratner, P. A., Balneaves, L. G., Richardson, C. G., McCullum, M., Hack, T., … Buxton, J. (2002). Women's interest in genetic testing for breast cancer risk: the influence of socio-demographics and knowledge. *Cancer Epidemiological Biomarkers and Prevention., 11*, 89–95.

Bruno, M., Tommasi, S., Stea, B., Quaranta, M., Schittulli, F., Mastropasqua, A., … Paradiso, A. (2004). Awareness of breast cancer genetics and interest in predictive genetic testing: a survey of a southern Italian population. *Annals of Oncology, 15*(1), 48–54.

Bruno, M., Digennaro, M., Tommasi, S., Stea, B., Danese, T., Schittulli, F., & Paradiso, A. (2010). Attitude towards genetic testing for breast cancer susceptibility: a comparison of affected and unaffected women. *European Journal of Cancer Care, 19*, 360–368. https://doi.org/10.1111/j.1365-2354.2009.01067.x.

Caulfield, T., Ries, N. M., Ray, P. N., Shuman, C., & Wilson, B. (2010). Direct-to-consumer genetic testing: good, bad or benign? *Clinical Genetics, 77*(2), 101–105.

Chen, S., & Parmigiani, G. (2007). Meta-analysis of BRCA1 and BRCA2 penetrance. *Journal of Clinical Oncology, 25*(11), 1329–1333. https://doi.org/10.1200/JCO.2006.09.1066.

Dandara, C., Greenberg, J., Lambie, L., Lombard, Z., Naicker, T., Ramesar, R., et al. (2013). Direct-to-consumer genetic testing: to test or not to test, that is the question. *SAMJ: South African Medical Journal, 103*(8), 510–512.

Durfy, S. J., Bowen, D. J., McTiernan, A., Sporleder, J., & Burke, W. (1999). Attitudes and interest in genetic testing for breast and ovarian cancer susceptibility in diverse groups of women in western Washington. *Cancer Epidemiology Biomarkers Prevention, 8*, 369–375.

Easton, D. F., Pharoah, P. D., Antoniou, A. C., Tischkowitz, M., Tavtigian, S. V., Nathanson, K. L., Devilee, P., Meindl, A., Couch, F. J., Southey, M., Goldgar, D. E., Evans, D. G., Chenevix-Trench, G., Rahman, N., Robson, M., Domchek, S. M., & Foulkes, W. D. (2015). Gene-panel sequencing and the prediction of breast-cancer risk. *New England Journal of Medicine, 372*(23), 2243–2257. https://doi.org/10.1056/NEJMsr1501341.

Fackenthal, J. D., Sveen, L., Gao, Q., Kohlmeir, E. K., Adebamowo, C., Ogundiran, T. O., … Olopade, O. I. (2005). Complete allelic analysis of BRCA1 and BRCA2 variants in young Nigerian breast cancer patients. *Journal of Medical Genetics, 42*, 276–281. https://doi.org/10.1136/jmg.2004.020446.

Fagbemiro, L., & Adebamowo, C. (2014). Knowledge and attitudes to personal genomics testing for complex diseases among Nigerians. *BioMed Central Medical Ethics, 15*(1), 34. https://doi.org/10.1186/1472-6939-15-34.

Forouzanfar, M. H., Foreman, K. J., Delossantos, A. M., Lozano, R., Lopez, A. D., Murray, C. J., & Naghavi, M. (2011). Breast and cervical cancer in 187 countries between 1980 and 2010: a systematic analysis. *Lancet, 378*(9801), 1461–1484. https://doi.org/10.1016/S0140-6736(11)61351-2.

Halbert, C. H., Kessler, L. J., & Mitchell, E. (2005). Genetic testing for inherited breast cancer risk in African Americans. *Cancer Investigation, 23*(4), 285–295.

Hughes, C., Gomez-Caminero, A., Benkendorf, J., Kerner, J., Isaacs, C., Barter, J., & Lerman, C. (1997). Ethnic differences in knowledge and attitudes about BRCA1 testing in women at increased risk. *Patient Education and Counseling, 32*, 51–62.

Ibrahim, N. A., & Odusanya, O. O. (2009). Knowledge of risk factors, beliefs and practices of female healthcare professionals towards breast cancer in a tertiary institution in Lagos, Nigeria. *BioMed Central Cancer, 9*(1), 76. https://doi.org/10.1186/1471-2407-9-76.

Jedy-Agba, E., Curado, M. P., Ogunbiyi, O., Ogaa, E., Fabowale, T., Igbinoba, F., … Adebamowo, C. A. (2012). Cancer Incidence in Nigeria: a report from population-based cancer registries. *Cancer Epidemiology, 36*(5), 271–278. e271–e278. https://doi.org/10.1016/j.canep.2012.04.007.

Jegede, A. S. (2009). Culture and genetic screening in Africa. *Developing World Bioethics, 9*(3), 128–137. https://doi.org/10.1111/j.1471-8847.2009.00259.x.

Kash, K. M., Ortega-Verdejo, K., Dabney, M. K., Holland, J. C., Miller, D. G., & Osborne, M. P. (2000). Psychosocial aspects of cancer genetics: women at high risk for breast and ovarian cancer. *Semin Surgical Oncology, 18*(4), 333–338.

Kessler, L., Collier, A., Brewster, K., Smith, C., Weathers, B., Wileyto, E. P., & Halbert, C. H. (2005). Attitudes about genetic testing and genetic testing intentions in African American women at increased risk for hereditary breast cancer. *Genetics in Medicine, 7*(4), 230–238.

Kessler, L., Collier, A., & Halbert, C. H. (2007). Knowledge about genetics among African Americans. *Journal of Genetic Counseling, 16*(2), 191–200.

Kinney, A. Y., Croyle, R. T., Dudley, W. N., Bailey, C. A., Pelias, M. K., & Neuhausen, S. L. (2001). Knowledge, attitudes, and interest in breast–ovarian cancer gene testing: a survey of a large African-American kindred with a BRCA1 mutation. *Preventive Medicine, 33*, 543–551.

Kinney, A. Y., Gammon, A., Coxworth, J., Simonsen, S. E., & Arce-Laretta, M. (2010). Exploring attitudes, beliefs, and communication preferences of Latino community members regarding BRCA1/2 mutation testing and preventive strategies. *Genetics in Medicine, 12*(2), 105–115. https://doi.org/10.1097/GIM.0b013e3181c9af2d.

Lerman, C., Seay, J., Balshem, A., & Audrain, J. (1995). Interest in genetic testing among first-degree relatives of breast cancer patients. *American Journal of Medical Genetics, 57*(3), 385–392. https://doi.org/10.1002/ajmg.1320570304.

Lerman, C., Narod, S., Schulman, K., Hughes, C., Gomez-Caminero, A., Bonney, G., … Lynch, H. (1996). BRCA1 testing in families with hereditary breast-ovarian cancer: a prospective study of patient decision making and outcomes. *JAMA, 275*(12), 1885–1892.

Lerman, C., Biesecker, B., Benkendorf, J. L., Kerner, J., Gomez-Caminero, A., Hughes, C., & Reed, M. M. (1997). Controlled trial of pretest education approaches to enhance informed decision-making for BRCA1 gene testing. *Journal National Cancer Institute, 89*(2), 148–157. https://doi.org/10.1093/jnci/89.2.148.

MacNew, H. G., Rudolph, R., Brower, S. T., Beck, A. N., & Meister, E. A. (2010). Assessing the knowledge and attitudes regarding genetic testing for breast cancer risk in our region of southeastern Georgia. *The Breast Journal, 16*(2), 189–192. https://doi.org/10.1111/j.1524-4741.2009.00880.x.

Mavaddat, N., Peock, S., Frost, D., Ellis, S., Platte, R., Fineberg, E., … Easton, D. F. (2013). Cancer risks for BRCA1 and BRCA2 mutation carriers: results from prospective analysis of EMBRACE. *Journal of the National Cancer Institute., 105*(11), 812–822. https://doi.org/10.1093/jnci/djt095.

Miki, Y., Swensen, J., Shattuck-Eidens, D., Futreal, P. A., Harshman, K., Tavtigian, S., … Skolnick, M. H. (1994). A strong candidate for breast cancer susceptibility gene BRCA 1. *Science, 266*(5182), 66–71.

Mogilner, A., Otten, M., Cunningham, J. D., & Brower, S. T. (1998). Awareness and attitudes concerning BRCA gene testing. *Annals of Surgical Oncology, 5*(7), 607–612.

Montazeri, A., Vahdaninia, M., Harirchi, I., Harirchi, A. M., Sajadian, A., Khaleghi, F., … Jarvandi, S. (2008). Breast cancer in Iran: need for greater women awareness of warning signs and effective screening methods. *Asia Pacific Family Medicine, 7*(1), 6. https://doi.org/10.1186/1447-056X-7-6.

Moyer, V. A., LeFevre, M. L., Siu, A. L., Peters, J. J., Baumann, L. C., Bibbins-Domingo, K., … Pignone, M. P. (2014). Risk assessment, genetic counseling and genetic testing for BRCA-related cancer in women: U.S. preventive task force recommendation statement. *Annals of Internal Medicine, 160*(4), 271–281. https://doi.org/10.7326/M13-2747.

Obaji, N. C., Elom, H. A., Agwu, U. M., Nwigwe, C. G., Ezeonu, P. O., & Umeora, O. U. J. (2013). Awareness and practice of breast self-examination among market women in Abakaliki, South East Nigeria. *Annals of Medical and Health Sciences Research, 1*(7), 7–12. https://doi.org/10.4103/2141-9248.109457.

Obajimi, M. O., Ajayi, I. O., Oluwasola, A. O., Adedokun, B. O., Adeniji-Sofoluwe, A. T., Mosuro, O. A., Akingbola, T. S., Bassey, O. S., Umeh, E., Soyemi, T. O., Adegoke, F., Ogungbade, I., Ukaigwe, C., & Olopade, O. I. (2013). Level of awareness of mammography among women attending outpatient clinics in a teaching hospital in Ibadan, South-West Nigeria. *BioMedical Central Public Health 13*(1), 14. https://doi.org/10.1186/1471-2458-13-40.

Odusanya, O. O., & Tayo, O. O. (2001). Breast cancer knowledge, attitude and practice among nurses in Lagos Nigeria. *Acta Oncologica, 40*(7), 844–848.

Okobia, M. N., Bunker, C. H., Okonofua, F. E., & Osime, U. (2006). Knowledge attitude and practice of Nigerian women towards breast cancer; a cross sectional study. *World Journal of Surgical Oncology, 4*, 11. https://doi.org/10.1186/1477-7819-4-11.

Olajide, T. O., Ugburo, A. O., Habeebu, M. O., Lawal, A. O., Afolayan, M. O., & Mofikoya, M. O. (2014). Awareness and practice of breast screening and its impact on early detection and presentation among breast cancer patients attending a clinic in Lagos, Nigeria. *Nigerian Journal of Clinical Practice, 17*(6), 802–807. https://doi.org/10.4103/1119-3077.144404.

Peters, N., Domchek, S. M., Rose, A., Polis, R., Stopfer, J., & Armstrong, K. (2005). Knowledge, attitudes, and utilization of brca1/2 testing among women with early-onset breast cancer. *Genetic testing, 9*(1), 48–53.

Quinlivan, J. A., Battikhi, Z., & Petersen, R. W. (2014). What factors impact upon a woman's decision to undertake genetic cancer testing? *Frontiers in Oncology, 3*(1), 325. https://doi.org/10.3389/fonc.2013.00325.

Sanderson, S. C., Wardle, J., Jarvis, M. J., & Humphries, S. E. (2004). Public interest in genetic testing for susceptibility to heart disease and cancer: a population-based survey in the UK. *Preventive Medicine, 39*, 458–464. https://doi.org/10.1016/j.ypmed.2004.04.051.

Satia, J. A., McRitchie, S., Kupper, L. L., & Halbert, C. H. (2006). Genetic testing for colon cancer among African-Americans in North Carolina. *Preventive Medicine, 42*(1), 51–59.

Sheppard, V. B., Graves, K. D., Christopher, J., Hurtado-de-Mendoza, A., Talley, C., & Williams, K. P. (2014). African American women's limited knowledge and experiences with genetic counseling for hereditary breast cancer. *Journal of Genetic Counseling, 23*(3), 311–322.

Sitas, F., Parkin, D. M., Chirenje, M., Stein, L., Abratt, R., & Wabinga, H. (2008). Part II: Cancer in indigenous Africans—causes and control. *The Lancet Oncology, 9*(8), 786–795. https://doi.org/10.1016/S1470-2045(08)70198-0.

Spruill, I., Coleman, B., & Collins-McNeil, J. (2009). Knowledge, beliefs and practices of African-American nurses regarding genetics/genomics. *Journal of National Black Nurses' Association: JNBNA, 20*(2), 20–24.

Struewing, J. P., Lerman, C., Kase, R. G., Giambarresi, T. R., & Tucker, M. A. (1995). Anticipated uptake and impact of genetic testing in hereditary breast and ovarian cancer families. *Cancer Epidemiological Biomarkers and Prevention, 4*(2), 169–173.

Su, P. (2013). Direct-to-consumer genetic testing: a comprehensive view. *The Yale Journal of Biology and Medicine, 86*(3), 359–365.

Suh, M. A., Atashili, J., Fuh, E. A., & Eta, V. A. (2012). Breast self-examination and breast cancer awareness in women in developing countries: a survey of women in Buea, Cameroon. *BioMed Central Research Notes, 9*(5), 627. https://doi.org/10.1186/1756-0500-5-627.

Tong, R. (2013). Ethical concerns about genetic testing and screening. *North Carolina Medical Journal, 74*(6), 522–525.

World Health Organization. (2002). Genomic and World Health/report of the Advisory Committee on Health Research. http://www.who.int/rpc/genomics_report.pdf.

World Health Organization. (2014). Cancer country profiles. Nigeria. http://www.who.int/cancer/country-profiles/nga_en.pdf?ua=1.